Evaluation of seeding rates and harvesting stages on forage biomass yield of triticale (X TRITICOSECALE WITTMACK) vs vetch (VICIA VILOSA R.) mixture DEMBIA DISTRICT, ETHIOPIA

By

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Abstract

Information on the agronomic management such as the stage of harvesting and optimum level of seeding rate for maximum biomass yield pastures mixture and biological compatibility of forage is generally inadequate. Hence the experiment was carried out to assess forage yield and biological compatibility of triticale (X Triticosecale wittmack) and vetch (*Vicia vilosa* R.) mixture grown under different seeding rates and stages of harvesting at Dembia district, Ethiopia. The objectives of the research were to evaluate the optimum stages of harvesting and proportion of seeding rates for the maximum biomass production and biological compatibility of triticale/vetch in the mixture and pure stands. The methods of the experimental design was employed a split plot design with three stages of harvesting as a main plot and five seed proportion as a sub plot and replicated three times. Data was subjected to analysis of variance using SPSS version 14 statistical packages. The results of the experiments, showed that, dry matter accumulation of triticale at 20th day of plant growth showed significant difference ($P<0.01$) among the different seed proportion treatments (Table 1). The highest and the lowest dry matter accumulation of vetch were recorded at the seed proportion three and seed proportion five with the value of 48.55 and 38.65 g/10 plants. Higher forage dry matter yield of the mixture was 11.85t/ha was observed at harvesting stage three and seed proportion three. Relative yield total was also found to be more than one in all HS at SP3. In SP3 at HS2, the highest value was 1.72 indicating yield advantages of 72% for triticale/vetch mixture as compared to sole cropping of either of the two forage species. In conclusion, this result showed that HS2 and SP3 were the best combination for better biomass yield and good biological compatibility in the mixture. Keywords: Seed proportions (SP), harvesting stages (HS), biological compatibility (BC), dry matter yield (DMY).

Keywords*:* Seed proportions (SP), harvesting stages (HS), biological compatibility (BC), dry matter yield (DMY).

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1. Introduction

Livestock production in the tropics can be increased through increasing the productivity per animal and per unit area of land. A major factor in increasing livestock production and productivity will be the improvement of animal nutrition and feed supplies, especially in case of ruminant animals. Improved animal disease and parasite control, breeding, and management will also be important, but initially a major emphasis must be placed on providing better nutrition (Whitman *et al.,* 1980). Natural grazing land of Ethiopia consists of largely wide range of grasses, less legumes and other herbaceous species. According to Daniel (1990) the existing feed stuffs in Ethiopia, native pasture and crop residues are poor in quality as well as in biomass yield which are insufficient protein, energy, vitamins and minerals (Osuji *et al*., 1993).

Triticale (X *Triticosecale Wittmack*) belongs to the grass family *(Poacea*) a hybrid resulting from the crossing of wheat "female parent" with a rye "male parent" (NRC, 1989). As to the origin of triticale, the first deliberate hybrid between wheat and rye, which was sterile, was reported in Scotland in 1875, while the first partially fertile hybrid was produced in Germany in 1888. However, the first breakthrough in producing fertile primary triticales came in France with the use of colchicines where in chromosome numbers of triticale have been doubled (Villarreal *et al*., 1990, as sited by Yibabe, 2002)

Triticale vegetation can be used in rural purpose systems where the triticale is grazed or cut in spring and then left for a grain harvest in summer to cut and carry or conserve as silage and after a grain harvest the straw can be fed to livestock and or the stubble may be grazed (mik, 1997).

Forage yield of triticale has been found to be almost equivalent with the yields of barley however, oat yielded significantly less dry matter than triticale and therefore wheat has the lowest dry matter yield than the other cereals, the mean digestible dry matter yields were 1.61, 1.43, 1.36, and 1.25 t/acre for barley, triticale, oat, and wheat, respectively and these means were over six maturity stages from flag leaf to dough stage. Triticale, cut slightly before boot stage makes the best silage similar to other small grains, but dry matter yields are higher at later maturity stages (Droushiotis, 1989).

Triticale species and the legume vetch have been identified to have a promising potential for pasture improvement. In addition, the Ministry of agriculture (MOA) for adoption by dairy cattle owners is testing the different legume species. However, information on their agronomical management such as the stage of harvesting and optimum level of seeding rate for maximum biomass production for mixed pastures to improve yield and biological compatibility of forage is generally inadequate. Therefore the objectives of this research were

1. To evaluate the optimum seeding rates and harvesting stages for maximum biomass yield of forages in the mixture.
2. To assess the biological efficiency of forage biomass yield and biological compatibility in the mixture.

2. Materials and methods

2.1 Study Area:

The experiment was conducted at *Dembia district*, North West of Ethiopia, 736 km North of Addis Ababa. The area experiences one main rainy (unimodal) with long rainy season extending from half of April to the mid October. But the effective rainfall is from May to half October. Mean maximum and minimum temperatures is 26.7 ^{0}C and 13 ^{0}C correspondingly. The area lies at an altitude of 2004 *m.a.s.l*. (Dembiya Agricultural Office, 2004).

2.2 Experimental Design and Treatments:

The experiment was conducted with three stages of cutting in the main plot which are boot stage, milk stage and dough stage of triticale and five seed rate proportions which are in triticale alone, triticale 75% + 25% vetch, triticale 50% + 50% vetch, triticale 25% + 75% vetch and vetch alone were employed as sub plots treatments. Thus all together 15 treatments were put in split plot design (SPD) and replicated three times with the total of 45 treatments plots.

2.3 Data Analysis:

All data were analyzed using SPSS version 14 for analysis of variance. Least significance different (LSD) was applied for mean separation.

3. Results and discussion

Dry matter accumulation of triticale at the 20th day of plant growth showed significant difference ($P<0.01$) among the different seed proportion treatments (Table 1). Seed proportion one and seed proportion three were significantly higher than the seed proportion two and seed proportion four.

Though the seed proportion of triticale reduced up to 50% seeding rate, the dry matter accumulation may not be reduced. The reason for seed proportion three may be due to both equally competitive on the utilization of soil resources that could contribute the better dry matter accumulation among the other seed proportion. The lowest dry mater accumulation was found at seed proportion two of the mixed forges (Table 1).

Table 1. Dry matter accumulation of triticale (g/10 plants) as affected by seed proportion

Seed proportion	Growing duration (in days)			
	20	40	60	80
SP1	2.37^{a}	13.23^{b}	31.65^{c}	70.44^{bc}
SP2	1.3^{b}	11.66^{c}	38.45^{b}	62.58^{d}
SP3	2.62^{a}	18.23^{a}	43.11^{a}	79.11^{a}
SP4	1.56^{b}	12.81^{bc}	37.80^{b}	70.64^{b}
SP5	-	-	-	-
Mean	1.96	13.98	37.75	70.69
SE (±)	0.116	1.130	0.502	0.917
LSD	0.757	1.622	2.496	6.358
CV (%)	12.56	19.53	8.56	6.69

Seed Proportion from 1 to 5, means with different letter within the columns are indicated significant different, whereas means with the same letter showed no significant.

Analysis of variance data was indicated that the dry matter accumulation was significantly affected ($P<0.01$) by the different seed proportion in the 40th days of harvesting of forage (Table 1). The highest dry matter accumulation was recorded at seed proportion three and the lowest at seed proportion two with the value of 18.23 and 11.66 g/10 plants respectively. Significant variation ($P<0.01$) was also observed in the dry matter accumulation of forage species at the different seed proportions at the 60th days of cutting (Table 1) above. The highest and the lowest dry matter were measured at seed proportion three and seed proportion one obtained 43.11 and 31.65 g/10 plans correspondingly. Except seed proportion four, the rest of the seed proportion showed an increasing tendency in which the amount of triticale seed is decreased up 50% seeding rate.

This is because of the companion crop mixture are in optimum combination for the efficient utilization of soil nutrients and light that could facilitated dry matter accumulation of the forage. In table one at the 80th days of harvesting of forage dry matter accumulation measurement indicated that, highly significant difference (P<0.01) was observed at seed proportion three. Nevertheless, seed proportion one and seed proportion four did not show an effect on the dry matter accumulation of the mixture.

Dry Matter Accumulation of Vetch as Affected by Seed Proportions

Analysis of variance revealed that dry matter accumulation showed significant different (P<0.01) was observed at the 20th days of harvesting (Table 2). While seed proportion two was the lowest dry matter accumulation measuring the value of 1.11g/10 plants. This is because of the succulent properties of plant tissue, which contain relatively high in moisture accumulation than the other seed proportions.

Table 2. Dry mater accumulation of vetch g/10 plants affected by seed proportion

Seed proportions	Cutting Days			
	20	40	60	80
SP1	-	-	-	-
SP2	1.11b	11.22a	27.99b	40.21bc
SP3	2.58a	10.99a	28.00b	48.55a
SP4	2.42a	12.22a	29.46a	40.18b
SP5	2.36a	11.55a	27.91b	38.65bc
Mean	2.12	11.50	28.34	41.89
SE (±)	0.014	2.781	1.24	2.354
LSD	0.840	NS	0.824	5.436
CV (%)	11.64	7.88	9.81	5.86

Seed Proportion from 1 to 5, means with different letter within the columns are indicated significant different, whereas means with the same letter showed no significant.

In table two, the 40th days of harvesting of forage indicated no significant different (P>0.05) at all seed proportions, even though there is a different in numerical values but statistically no significant variation was observed. This might be in equally in maturity, their physiological activity was well performing, and the soil variation between the different seed proportion in the different plots may not have significant effect on the dry matter accumulation of forages in the mixture. Analysis of variance data revealed that significant different (P<0.01) was observed in the dry matter accumulation of vetch at 60th days of harvesting in the different seed proportion (Table 2). The highest and the lowest dry matter accumulation were measured at seed proportion four and seed proportion five with the value of 29.46 and 27.91g/10 plant respectively and seed proportion three was also optimal as compared to other seed proportion. Harvesting of forage at the 80th days of plant growth indicated significant variation ($P<0.01$) the dry matter of the different seed proportion (Table 2). The highest and the lowest dry matter accumulation of vetch were recorded at the seed proportion three and seed proportion five with the value of 48.55 and 38.65 g/10 plants.

In table three, yield of triticale and vetch mixture were highly significant ($P<0.01$) in all the cases of harvesting stage and seed proportion. The highest mean dry matter yield was obtained at seed proportion three with the value of 8.41t/ha and the lowest at seed proportion five with the value of 6.15 t/ha. In table 5, the interaction effect also showed significant difference ($P<0.01$) in both factors of forage species. The various harvesting stage also indicated significant effect on the dry matter yield of the mixture in addition the highest and the lowest result were measured at harvesting stage three and one.

Table 3. Dry matter yield (t/ha) triticale/vetch mixture affected by Harvesting stages and seed proportions

Seed proportion	Harvesting stages			
	HS1	HS2	HS3	Mean
SP1	6.56a	9.58a	12.89a	9.68a
SP2	3.85bc	7.56b	9.85c	7.10b
SP3	4.40b	8.98a	11.85b	8.41c
SP4	4.03bc	7.12bc	8.85d	6.33d
SP5	3.52cd	6.65c	8.28d	6.15d
Mean	4.47	7.78	10.34	
	HSs	SPs	HSsxSPs	
SE (±)	0.27	0.17	0.31	
LSD	1.55	0.66	2.49	
CV (%)	6.26	6.26	6.26	

Seed Proportion from 1 to 5, means with different letter within the columns are indicated significant different, whereas means with the same letter showed no significant.

In table three above, harvesting stages and seed proportion significantly affected ($P<0.01$) the total dry matter yield of vetch component in the mixture. The rate of dry matter production in crops depends on the efficiency of the interception of photosyntheically active radiation (Biscoe and Gallagher, 1977) and Donald (1963) emphasized that light differed from other growth resources in that it could not be regarded as a reservoir from which demands could be made as required. Because of this, light was probably the most important factor when better temporal use of resources was achieved better production of dry matter yield.

In table four below, the highest and the lowest dry matter yield were found at harvesting stage three and harvesting stage one with the value of 5.87 and 2.23 t/ha respectively. The dry matter yield of the legume component was also affected by both in the different seed proportions. Significantly higher (P<0.01) of dry matter yield of the mixture was found at seed proportion three measuring 3.95 t/ha as compared to the other. An increasing trend was observed between harvesting stage two to harvesting stage three.

Table 4. Dry matter yield (t/ha) of vetch component as affected by harvesting stages and seed proportions

Seed proportion	Harvesting stages			
	HS1	HS2	HS3	Mean
SP1	-	-	-	-
SP2	0.95b	2.78c	4.80b	2.84c
SP3	2.67a	4.24b	4.93b	3.95b
SP4	1.77b	4.00b	5.46b	3.74b
SP5	3.52a	6.65a	8.28a	6.15a
Mean	2.23c	4.42b	5.87a	
	HSs	SPs	HSsxSPs	
SE (±)	0.062	0.125	0.217	
LSD (0.01)	0.401	0.865	0.898	
CV (%)	11.31	11.31	11.31	

Seed Proportion from 1 to 5, means with different letter within the columns are indicated significant different, whereas means with the same letter showed no significant.

Dry Matter Yield of Triticale (DMY) (t/ha)

The dry matter yield of grass component was also affected both by harvesting and seed proportions (Table 5). The highest dry matter yield was found at harvesting stage three with the value of 7.08 t/ha and the lowest value at harvesting stage one with the value 3.36t/ha respectively. The different types of seed proportion was also significantly affected (P<0.01) the dry matter contents of triticale component and the highest and the lowest value were seed proportion one and seed proportion four which indicted 9.68 and 2.95 t/ha correspondingly

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Table 5. Dry matter yield (t/ha) of triticale component as affected by harvesting stages and seed proportion

Seed proportion	Harvesting stages			
	HS1	HS2	HS3	Mean
SP1	6.56a	9.58a	12.89a	9.68a
SP2	2.90b	4.78b	5.05b	4.24b
SP3	1.77b	4.74b	6.92b	4.48b
SP4	2.26b	3.12b	3.46c	2.95c
SP5	-	-	-	-
Mean	3.36c	5.56b	7.08a	
	HSS	SPs	HSs X SPS	
SE (±)	0.16	0.24	0.41	
LSD	1.06	1.86	3.08	
CV (%)	7.85	7.85	7.85	

Seed Proportion from 1 to 5, means with different letter within the columns are indicated significant different, whereas means with the same letter showed no significant.

Biological Efficiency (BE) of Triticale /Vetch Mixture

Botanists defined plant interference as the response of on individual plant or species to its environment and modified by the presence of another individual plants or species (Donald 2002). Interference occurs among plants of the some species in pure stands and among plants of different species in intercropping systems. Such interference can be non-competitive or complements. Non-competitive interference occurs when different plants share a growth factor (light, water and soil nutrients) that is present in sufficient amount so that it is not limiting (Tilahun, 2002).

A competition function is proposed as a measure of intercrop competition to indicate the number of times by which one component crop is more competitive than the other (willey and Rao, 1980). This competition function could be use full, to compare the competitive ability of different crops and to measure competitive changes within a given combination which can identity which plant character is associated with competitive ability therefore it could determine what competitive balance between component crops is most likely to give yield advantage. The competition functions which have been widely used are relative crowding coefficient (De Wit, 1994).

Relative Yield Total (RYT) or Land Equivalent Ratio (LER)

In table six below, harvesting of forage at milk stages resulted with the value of 1.72. This is equivalent to 72 percent more yield advantage at seed proportion three as compared to sole cropping). When these two component crops were sown with equal seed proportion (50:50) and harvested at dough stage, the relative yield total (RYT) was 1.19 and the yield advantage was found to be 19 and 15 % with respect to seed proportion three and seed proportion two correspondingly. Harvesting of forage at boot stages and sowing (50:50) triticale/vetch mixture accounted for the maximum RYT of 1.72 that indicated a yield advantages of 72 percent. In table sixt below, the relative yield total (RYT) does not only give a better indication of the relative competitive ability of the component crops, but also it indicated the actual advantages due to intercropping. The intercropping system resulted in higher cumulative total biomass yield than either of the pure stand crop, which resulted in higher relative yield total value than the sole cropping.

The higher cumulative total biomass yield was supposed to be resulted due to increase in light use efficiency of the intercrops, which resulted in higher cumulative leaf area of the intercrops. Usually yield advantage occurs because component crops different in their use of growth resources in such a way that when they are grown in combination they are able to complement each other and so make better overall resource utilization than when they are grown separately. This means that in some way the component crops are not competing for exactly the same resources (Temado, 1994).

Table 6. Relative yield total in the mixture as affected by seed proportion and harvesting stages

Seed proportion	Harvesting Stages								
	HS1			HS2			HS3		
	RYG	RYL	RYT	RYG	RYLG	RYT	RYG	RYLG	RYT
SP2	0.22	0.49	0.71	0.25	0.74	0.99	0.26	0.89	1.15
SP3	0.78	0.36	1.14	0.87	0.85	1.72	0.56	0.63	1.19
SP4	0.38	0.37	0.75	0.36	0.26	0.62	0.72	0.27	0.99

HS1-3 = Harvesting stage from one to three, SP3-5 = Seed proportion from three to five, RY = Relative yield, RYT= Relative yield total, LER = Land equivalent ratio

The result of this study was in agreement with the findings of Ibrahim et al. (1993) who reported a similar result in sorghum lablab intercropping. Jaballa (1995) also stated that intercropping (IC) treatments had higher combined leaf area than sole crop treatments.

Relative Crowding Coefficient (RCC)

In table ten below, the biological compatibility of the two component crop species in relation to RCC indicated that, when the forage crop mixture was harvested at milk stage, under different seed proportion conditions, triticale was found to be a dominant species over vetch, but product of RCC of 50:50 triticale and vetch appeared to at an acceptable range, since the same has been computed for crowding coefficient greater than one with the product of 3.87 was observed. The product of crowding coefficient further indicated an advantage of mixing triticale and vetch either at

25:75 or 50:50 due to the fact that these patterns had produced products of crowding coefficient greater than one with the value of 3.87 at HS2 and SP3 respectively.

Table 7. Relative crowding coefficient (RCC) of the mixture as affected by harvesting stages and seed proportions

Seed proportion	Harvesting stages								
	HS1			HS2			HS3		
	T	V	K (TxV)	T	V	K (TxV)	T	V	K (TxV)
SP2	0.86	1.89	1.63	1.02	0.95	0.97	1.08	2.65	2.86
SP3	1.21	0.55	0.67	2.21	1.75	3.87	1.27	1.68	2.13
SP4	0.62	0.95	0.59	0.58	1.03	0.60	0.86	0.10	0.95

HS1-3 = Harvesting stage from one to three, SP3-5 Seed proportion from three to five, RCC = Relative crowding coefficient, K= Coefficient, T= Triticale, V= Vetch.

4. Concolusion

In general with all these important forage yield parameters and other useful morphological characteristics, it can be conclude that, seed proportion three associated with harvesting stage two (milk stage) would be recommended for improved optimal forage production which can defeat the on hand livestock feed problems particularly in the central and central highlands of Ethiopia due to their mixed farming agricultural system where triticale and vetches are grown successfully. The performance of the intercropping is much more dependent on the assortment of compatible crop type and varieties. It is therefore indispensable to study the different varieties of triticale and vetch so as to identify the compatible ones. Intercropping of forage is known to have a significant role in improving the nutritional status of the soils and hence increases the forage yield. It is therefore important to study the effect of trtiticale / vetch intercropping on soil fertility and its high impact on forage biomass yield. Assessment along with the effect of feed intake and animal productivity trial such as milk and meat production, body weight gain are required to develop triticale / vetch mixture based diets for small holder farmers in the highlands of Ethiopia. In conclusion, the current experiment should be conducted on different agro ecological areas and soil types and forage chemical analysis where triticale and vetches are grown and expected to be potential feed sources for livestock feeding.

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